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EUROPEAN SCIENTIFIC NOTES. VOLUME 32, NUMBER 7,(U)

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OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 32-7

31 July 1978

DEPARTMENT OF THE NAVY
O. N. R. LONDON BRANCH

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) ESN-32-7	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) EUROPEAN SCIENTIFIC NOTES. Volume 32, Number 7,		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A.W. PRYCE & V.S. HEWITSON, editors		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research Branch Office London Box 39 FPO New York 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS (10) Aubrey W. Pryce Victoria S. Hewitson		12. REPORT DATE (11) 31 July 1978
		13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) (12) 36p.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

AERONAUTICS	MATHEMATICAL SCI
ENGINEERING	PHYSICAL SCI
GENERAL	PSYCHOLOGICAL SCI
MATERIAL SCI	SPACE SCI

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with occasional articles prepared by, or in cooperation with, members of scientific

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EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Aubrey W. Pryce and Victoria S. Hewitson

31 July 1978 Volume 32, No. 7

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European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

AERONAUTICS

HIGH-PRESSURE OPERATION—ENGLAND AND FRANCE

No! It's not the World Cup. England and France have just put into operation similar large wind tunnels capable of high Reynolds number operation through pressurization. In England, the Royal Aircraft Establishment (RAE) has just commissioned its 5-m tunnel which is under the direction of Mr. A. Spence, Head of the Low Speed Aerodynamics Division. Located at Farnborough, the facility is 60 km southwest of London. Contractor testing commenced in May 1978. France's Office National d'Etudes et de Recherches Aérospatiales (ONERA) began full-time operation of their 4.5-m tunnel F-1 at Le Fauga last year. This new facility is located at an old army base 30 km south of Toulouse. Mr. A. Masson heads the F-1 tunnel operation at Le Fauga where the first industrial experiments were conducted in August 1977.

These new wind tunnels have an ability to vary the air pressure in the tunnel while maintaining a constant flow velocity. Most wind tunnels operate at one pressure only, atmospheric, with the result that the fluid phenomena represented are those at the model scale in the tunnel. The ability to increase pressure above one atmosphere allows flow conditions more representative of full-scale flight to be duplicated. In particular, the Reynolds number, a scaling factor that is a function of both model length and air pressure can be varied. The pressure tunnel can simulate a number of flow conditions up to full-scale while using a single sub-scale model to represent the aircraft.

Large high-pressure subsonic wind tunnels provide the capability to study the low-speed aerodynamics of modern aircraft and their associated high-lift systems. The recurring demand for better take-off and landing characteristics, in conjunction with the high-wing loading required for high-speed performance, has made it necessary for almost all aircraft, both military and civil, to have complex aerodynamic systems to achieve high-lift coefficients. Leading edge slats, slotted flaps, and/or blowing adorn modern high-performance aircraft to provide the increase in lift necessary for take-off and landing. The rewards for achieving better take-off capability for a given runway length or for reducing landing approach speeds are at least as significant as improvements in the high-speed part of the flight envelope. The current emphasis on reducing noise in the vicinity of airports and the military interest in short take-off and landing (STOL) has resulted in even greater attention being placed on the high-lift, low-speed behavior of advanced aircraft designs.

In the low-speed regime of such high-performance aircraft, high local air velocities occur, particularly near the leading edge, and result in significant flow effects; hence, the importance of conducting model evaluation at a flow velocity, Mach number, corresponding to full-scale flight. The small chord of the slats and flap components makes it desirable to conduct these experiments at Reynolds numbers which are as high as possible and to use large models so that the slat and flap supports can be represented clearly. Hence, the desire for a large subsonic wind tunnel capable of pressurization to obtain higher Reynolds number flow conditions.

By virtue of their size and pressure range, the new tunnels can be used to evaluate scale models of fighter aircraft, such as the US Navy F-18, at near full-scale flow conditions. For models of transport aircraft of the size of a European airbus (A300B), Reynolds numbers nearly a quarter full scale can be achieved. But even more importantly, since experiments can be conducted over a broad range of Reynolds numbers at constant Mach number, scale effects can be determined thus giving a firm base from which to extrapolate to full-scale flow conditions.

The RAE and ONERA tunnels have broad and largely overlapping ranges of operating condition as shown in Fig. 1. Once a tunnel is pressurized, it may become necessary to make modifications to the model, and it is clearly desirable to do so at atmospheric pressure for safety considerations. One of the unique features of both tunnels is the isolation of the working section from the rest of the circuit so that 1 atm exists in the working section while the rest of the tunnel circuit remains pressurized although this is achieved somewhat differently in the two tunnels.

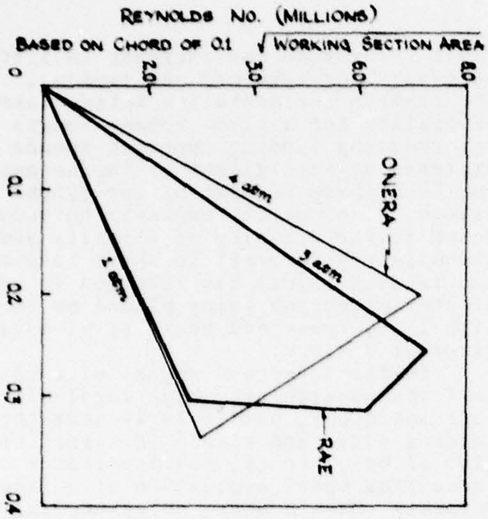
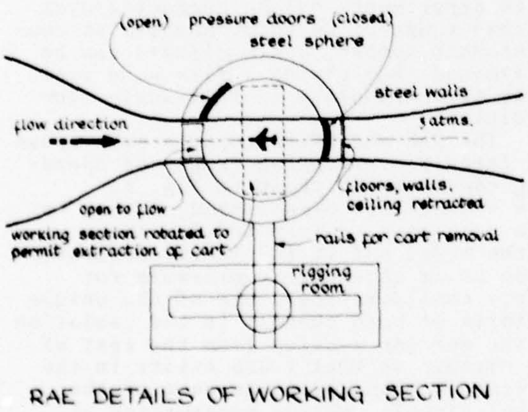


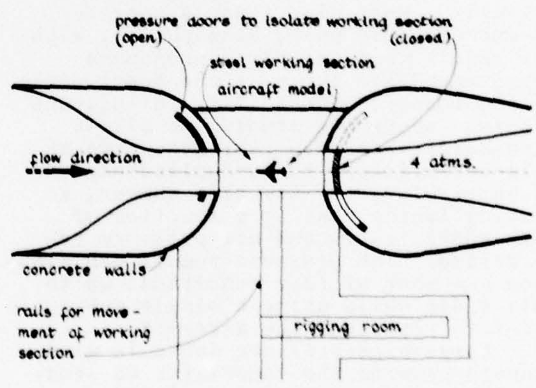
FIG. 1 OPERATIONAL RANGE

The RAE tunnel has a working section 5-m wide, 4.2-m high, and 12-m long, and can be pressurized to 3 atm in approximately 45 min. Two concentric spheres surround its working section. Panels in the upstream and downstream ends of the working section walls can be rotated inward clearing the section between the spheres. Large pressure doors on the outside of the inner sphere are then swung across the air passage and closed on the inner sphere (see diagram). The inner sphere can then be de-pressurized to give personnel access to the model in the working section. Another unique feature of this tunnel is the ability to change the entire model installation at one time. This is accomplished by rotating the entire working section 90° about a vertical axis. This aligns the section with an access tube through the spheres through which the model on its sting support attached to the floor can be removed on a cart as a unit. The cart then moves on rails into a large rigging room. Model set-up, check-out, and final tear-down occur here. This allows the tunnel to be maximized for wind-on experimentation. A total of 6 min is needed to stop the fan, get the pressure doors into position, de-pressurize the inner sphere, and obtain access to the model. The time required to interchange the model carts has been estimated at 30 min.

The ONERA facility uses a somewhat different design philosophy. Their F-1 tunnel is 4.5-m wide, 3.5-m high, and 8-m long and can be pressurized to 4 atm. Two large doors located at the forward and aft of the working section rotate and seal off the working section from the wind-tunnel circuit (see diagram)



RAE DETAILS OF WORKING SECTION



ONERA DETAILS OF WORKING SECTION

so that access at 1 atm is possible. It is then possible to remove the entire steel test section. The section moves laterally on rails to a rail junction. At this point a palette containing the model, support system, and tunnel floor

is removed from the working section to an individual set-up room. Each palette contains its own data acquisition system consisting of an HP minicomputer and associated analog-to-digital converters and amplifiers. In addition to model set-up and tear-down, a complete check-out of the data acquisition system can be accomplished in this set-up area. The type of models tested in this facility usually have a large quantity of individual pressure measurements, perhaps 1000. The ability to pre-check the electronics and software prior to tunnel entry is a valuable asset.

The model supports for both tunnels are designed for either sting or strut support. The RAE sting has a pitch range of +29° to -9° while ONERA's is 35° to 10°. Arrangements have been made for interchangeability of model support equipment between tunnels, allowing for easy inter-operability of models for international projects such as the Airbus. Both facilities have the most modern instrumentation and data handling systems for measuring, recording and processing, pressures, forces, temperature, and other physical quantities of interest. As previously stated, ONERA facility is equipped with individual minicomputers on each palette, thus data is processed and recorded during the tunnel run. The RAE facility has analog-to-digital amplifiers on the cart and transmits high amplitude signals to a central data center for processing and output of the data. Both facilities are equipped with on-line data reduction and plotting equipment.

The tunnels differ in construction in significant ways. The RAE tunnel is constructed entirely of high-grade stainless steel. The main drive consists of a large 11-MW ac motor and a smaller 1.6-MW dc motor located inside the pressure shell in the back section of the circuit. These motors are used separately or together to give flexibility in operation and good control extending down to low speeds without concern for variations in electrical supply frequency and voltage. The fan system is comprised of a 10-bladed, single-stage, fixed-pitch fan made of glass fiber and epoxy. The ONERA tunnel, on the other hand, is constructed primarily of reinforced concrete, except the motor housing and working section which are of steel. Its main drive consists of a constant-speed 9.5-MW ac motor located outside the pressure shell. This motor is shaft-coupled to a steel-bladed variable-pitch fan that turns at 350 rpm. In 1976 the ONERA tunnel began shakedown operation with aluminum alloy blades installed in the fan. Subsequently, a structural failure of one of the blades caused a one-year delay in commissioning. The aluminum alloy blades were replaced by heavier steel blades that were designed to match those that have been in use in the large French transonic tunnel (S1) at Modane for many years.

Both the RAE and ONERA tunnels have computer monitoring of the complete power plants including critical areas, temperatures, and strains. The computer alerts personnel if anything goes out of normal range. The operation can also be automatic with pre-programming of the experimental conditions to be studied. Thus programmed, an experiment can be automatically conducted under computer control in either tunnel.

These two large wind tunnels open a most important flight regime to exacting experimental examination and evaluation. One may ask as to the necessity of two facilities with operational envelopes offering such similar experimental conditions. Is there sufficient work to permit economical operation of both tunnels? This will depend on the future European development of military and civil aircraft. The ability to study advanced high-lift systems at near full-scale Reynolds number is certainly justification to the aerodynamicist.
(C. Joseph Martin, Liaison Technologist from David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland)

ENGINEERING

A WORLDWIDE PLUG AND SOCKET SYSTEM?

To facilitate international commerce, the International Electrotechnical Commission (IEC) in Geneva, with 42 member countries, last year proposed a new plug and socket system for 250-V ac use, which is rated at 16 amperes (maximum). The plug (Fig. 1), with two or three parallel flat prongs (intentionally incompatible with the American plug and others), is to be molded onto the end

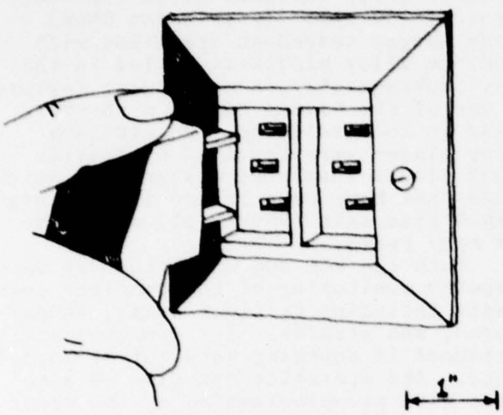


Fig. 1.

THE PROPOSED 16-A TWO-PRONG PLUG AND TWIN THREE-PRONG SOCKETS

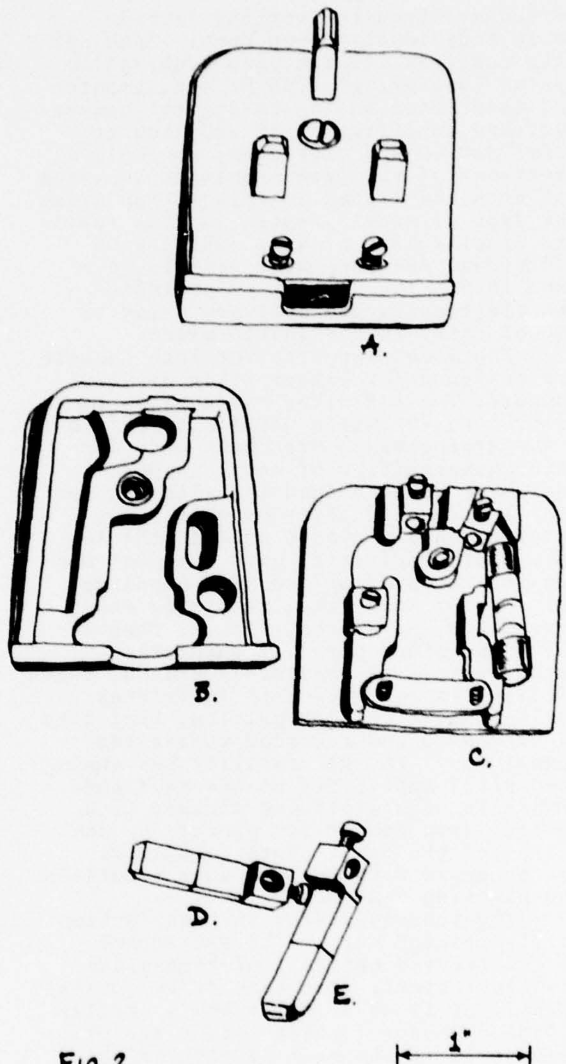


Fig. 2.

A. THE BRITISH 13-A PLUG

B. UNDERSIDE OF COVER

C. TERMINAL, FUSE, AND CORD CLAMP

D. NEUTRAL PRONG

E. GROUND PRONG

of the cord, thus tending to ensure its correct connection. In Britain, where appliances are always sold without plugs (for reasons that emerge below), deaths result every year from incorrectly connected three-prong plugs despite the standard color-coding of the wires in the cord.

In the UK and Ireland the new system, if accepted, would replace the present 13-A standard, which was adopted in 1952. The 13-A plug (Fig. 2) holds a fuse which is intended to match the power requirement of the appliance it feeds, although the 13-A fuse supplied with the plug is often used instead. The 16-A plug is unfused, however, and it is thus much smaller and lighter. In fact, twin 16-A sockets can fit into the space occupied by a single 13-A socket.

The 13-A socket incorporates shutters for the power-prong holes, which are raised as the longer ground prong enters its hole. The 16-A socket includes shutters as an option, which would very likely be adopted in Britain. The 16-A socket is recessed to prevent touching the prongs while they are energized (and to help support the plug), while the 13-A plug in its latest version depends for this purpose on insulating sleeves covering the first portion of each power prong.

Along with the 13-A socket came the philosophy of the "ring" circuit, which saves on copper by running a 15-A cable from a 30-A fuse near the meter to a large number of sockets and then back to the same fuse. The high rating of this fuse is the reason for individual smaller fuses on the 13-A plugs, as their cords might be so long and thin as to draw less than 30 A when short-circuited. If 13-A sockets on ring circuits are replaced with 16-A sockets, it is likely that the latter will be required to incorporate individual fuses or circuit breakers. Circuit breakers could, in fact, take the place of the toggle switches that are frequently part of the British socket. In the interest of safety, such a switch is usually used to shut off an electric stove—and its clock—when not cooking as well as to turn other appliances on and off.

The earlier British philosophy of electric wiring was the "radial" circuit, which led from a 5-A, 10-A, or 15-A fuse near the meter to a single 15-A socket or to one or more 5-A or 2-A sockets and lights. The 2-A, 5-A, and 15-A plugs were small, medium-sized, and large, respectively, with two or three round prongs, the six varieties being completely incompatible with one another. Numerous other types of plugs were in earlier use, as well. Although much new wiring has been added to older buildings and much old wiring has been updated, these older sockets are still in wide use, with a considerable variety of them (intended for appliances of different power requirements) as well as newer 13-A sockets adoring the baseboards. British households are thus often well equipped with adapters, and these may be carried around with the vacuum cleaner if it does not have an extremely long cord.

In addition to all this, the home of an American in Britain may include some US-type sockets fed by the roughly 110-V side of one or more step-down transformers, which he acquires in order to power appliances from home. US clocks and phonographs, however, cannot be used in this manner, as the 50-Hz supply frequency would stretch each minute by 20% and would lower all musical sounds by a minor third.

The unfused plug widely used in Europe, which is like the British 5-A, two-prong plug, is felt to be dangerously (conveniently?) compatible with the 13-A socket, as it will fit if the shutters are forced out of the way. This compatibility is among the reasons Britain voted for the 16-A standard in an IEC ballot a few months ago. Another reason was the desire to exercise some influence over the final design as well as to keep the UK aligned with the EEC, which may some day endorse the 16-A standard, thus forcing Britain to adopt it. The UK, however, was in the minority on the vote, and the 16-A standard was sent back to the IEC for further study, as many countries are happy with their present plugs.

Despite the official British support, sentiment in the UK seems to oppose the new standard because it is unfused and because its adoption would be expensive. In fact, Britain continues to feel the burden of the standard adopted in 1952, and it is clear that a whole generation would have to pass before any new standard would be fully implemented. Only then could it begin to achieve cost savings for the public as a whole. In the interim, Britons would be making do by adding fused adapters for 16 A to their present kits.

The 16-A plug would, however, assist Britain's electrical industry with its exports, would be neater and cheaper than the 13-A plug and would be safer in regard to both correct wiring and anchoring of the cord to the plug. The 13-A plug has usually included a fiber cord clamp whose threads are readily stripped, and, when it then becomes loose, the ground wire is likely to be the first to be pulled from its mooring, thereby posing the threat of its touching the "hot" side of the line.

While the 16-A plug continues to be a focus of controversy in Britain, it appears to represent an idea whose time will eventually come. Since it is intended only for 250 V, it may well never see service in the US, but developing countries seeking a standard to adopt might be the first to implement it. (Nelson M. Blachman)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

ACOUSTIC SHIP RECOGNITION AND ELECTRO-OPTICS AT C.I.T.-ALCATEL, PARIS

Among the adventurous aspects of a scientific-liaison visit is its unpredictability. Having received several reprints in 1972 from Claude Cardot of the C.I.T.-ALCATEL Laboratoires de Marcoussis and having made use of some of his ideas regarding Walsh functions in a paper of my own, I thought it would be good to try to see him (and others) during the course of a few days in Paris. It turned out that he had moved from Marcoussis to a nearby C.I.T.-ALCATEL location in Villarceau, which is devoted entirely to telephone systems. Although I did manage to see him, my visit was confined entirely to the Marcoussis facility, which covers a wide range of activities in the fields of lasers, optical communications, energy, and batteries, serving now as the CGE Group's corporate research center. Support for the Laboratories' work comes not only from within CGE but also from several agencies of the French government.

Marcoussis is a village 20 km south of the southwest edge of Paris, and the laboratories there employ 500 people in a rural complex of modern, well-equipped buildings, established in 1958. My host was Dr. Hubert Debart, who heads the Laser Department and who also works on underwater acoustics on a part-time basis at a C.I.T.-ALCATEL facility in Arcueil, 2 km south of Paris.

Before getting into the details of the Laboratoires' work and that of Debart, it seems appropriate to explain the acronyms. C.I.T.-ALCATEL stands for Compagnie Industrielle des Télécommunications, Société Alsacienne des Constructions Atomiques et Télécommunications Electroniques. This organization, with 33,000 employees, is the largest of the many subsidiaries of the Compagnie Générale d'Electricité (CGE), which has, in addition, 30% interests in two other companies with 65,000 people between them, giving it a grand total of 170,000 employees.

CGE's activities include cables, materials, computers, naval construction, and civil engineering as well as heavy and light electrical engineering. While research with optical-fiber fabrication and utilization is carried on at the Laboratoires de Marcoussis, the manufacture of optical-fiber cables is part of the work of the CGE subsidiary Cables de Lyon with 8,400 people. Other subsidiaries produce devices, such as batteries, that are developed in Marcoussis. The work on Na-S elevated-temperature batteries has been described by A. Sosin in *ESN* 31-6:219 and in ONRL-R-5-77. Some of the current research in this area concerns the use of metal electrodes to hold the Na and the S. The sodium polysulfides corrode Al, but Cr coating may alleviate the problem.

In the field of optical fibers, which Marcoussis has been exploring since 1972, a bandwidth-length product in the range from 0.5 to 1.2 GHz-km has been obtained by the use of high-silicon glass. Splices have been developed for joining lengths of optical fiber, and the bending of fibers has been investigated with a view to distributing a fraction of the light from inside to intermediate locations. (This would evidently not be a practical means for surreptitious tapping of optical fibers because any effort to strip off the material surrounding a fiber in an installed cable would very likely sever the fiber.) Repeaters suitable for use on the seabed are being developed; these will read out the signals and generate new, clean versions after the light pulses have become weak and wide as a result of propagation over some distance.

Other electro-optical work includes the fabrication of experimental photodiode arrays. One of these, an 8 × 128 array of 0.6-μm diodes, is intended for reading out an optical memory; another, a pair of 0.25 × 0.25-μm photodiodes, is to be used in the radiometer aboard the meteorological satellite METEOSAT.

Debart's Laser Department has built, among many other types, high-power Nd-doped-glass lasers producing 100-psec. (= 10^{-10} sec) pulses of 1-TW (= 10^{12} W) power at a 1.06-μm wavelength every 10 min by Xe-flash pumping of a rod 64 or 125 mm in diameter and 20 cm long. (Also see V.N. Smiley in *ESN* 31-9:375.) These have been sold to KMS Fusion, the Lawrence Livermore Laboratory, and the Limeil Center of the French AEC for use in fusion research.

Within the Laser Department, G.C.A. Roger is investigating the pulse-compression technique for use in laser ranging (lidar). By passing a frequency-swept pulse through a dispersive medium, he achieves a 400:1 shortening of the pulse from 20 μsec to 50 nsec. (However, it seems it would be possible

to get the laser to deliver all of its energy in the shorter interval, avoiding the need for compression.) There is, in addition, much other work in electro-optics, materials, etc.

Debart in his underwater-acoustic work is investigating a passive acoustic method for identifying ships and submarines as they pass over an array of hydrophones suspended at a depth of perhaps a mile. By analyzing the outputs from a suitable pair of elements in the array, he is able to determine the length and structure of the vessel and perhaps even the disposition of its cargo. His approach makes use of the sound emitted by the ship within a narrow band, such as 795-805 Hz. As long as the range of distances between any submerged part of the ship and either of the two hydrophones is small compared with the wavelength of sound in water at a typical difference frequency (e.g., 803 Hz - 800 Hz = 3 Hz), the sound field can be considered quasi-monochromatic, and the following approach is applicable.

We let $k = 1/\lambda$ be the wave number of the sound at the central frequency (800 Hz), and we let $f(x)$ be the complex amplitude of the sound radiated at around this frequency from the part of the ship at distance x forward of its center (Fig. 1). For a hydrophone at angle θ forward of the same point (or one a cone of half-angle $90° - \theta$ with axis along the length of the ship), the contribution from the part of the ship with coordinate x will be advanced by $2\pi kx \sin\theta$ radians by

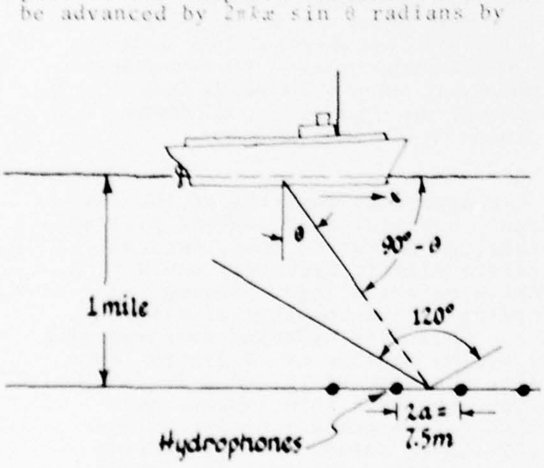


Fig. 1 Ship and Hydrophone Array

comparison with that from $x = 0$. In addition there will be a phase advance by $\pm 2\pi ka \sin\theta$ for hydrophones whose distance apart (when projected along the ship's axis) is $2a$.

Integrating over the length of the ship, we see that the complex sound amplitudes received by the two hydrophones are proportional to $\int f(x) \exp[2\pi ik'(x \pm a)]\, dx = F(k') \exp(\pm 2\pi ik'a)$, where $k' = k \sin\theta$ and $F(k')$ is the Fourier transform of $f(x)$. By dealing with the analytic signals from the two hydrophones, Debart is able to-multiply one complex amplitude by the conjugate of the other, thus getting $|F(k')|^2 \exp(4\pi ik'a)$, whose phase $4\pi k'a$ gives the value of k' and whose magnitude $|f(k')|^2$ Debart obtains each second during the time θ varies from +60° to -60°, this time being short enough that the ship is unlikely to change its course, speed, etc.

By computing the inverse Fourier transform of $|f(k')|^2$, Debart obtains the autocorrelation function of $f(x)$, namely, $R(u) = \int f(u + x) f^*(x)\, dx$, where f^* is the complex conjugate. This correlation function exhibits a series of peaks corresponding to *the distances* between the region of acoustic emission and provides an indication of the bulkhead separations as well as the length of the ship and perhaps even the loading of its compartments.

The foregoing analysis treats the ship as one-dimensional. However, the utilization of a pair of hydrophones on a line perpendicular to the ship's length may provide information about the structure in that direction.

The fact that $|f(k)|^2$ is obtained only for $-\sqrt{3}k/2 \leq k' \leq \sqrt{3}k/2$ means that some of the details of $R(u)$ are smeared out, but sufficient information remains for the discrimination of ship structures. The reconstruction of this information is aided, Debart suggests, by the use of Karhunen-Loève eigenfunctions for representing $|f(k')|^2$ in the form of a series, which can be inverse Fourier transformed term by term to get a better approximation to $R(u)$.

Analyzing magnetic tapes recorded in the Mediterranean off Villefranche by the French Navy with an array of 2600 hydrophones, Debart has successfully obtained known ship structures to within a 2-m resolution. For this purpose he utilized the outputs of just two of the hydrophones, which were 7.5 m apart. The next step will be to try to determine the structure from the observations without advance information about the ships. (Nelson M. Blachman)

PUTTING YOUR FOOT DOWN IN TEL AVIV

The Faculty of Engineering at Tel Aviv University consists of a series of discipline-oriented departments rather than the traditional subject groupings more often found in universities within and without Israel. Presently approved departments are: Fluid mechanics and heat transfer; solid mechanics, materials, and structures; electronics; interdisciplinary studies, including bioengineering; industrial engineering and manufacturing technology; control and computers; and energy. The last two are in the development stage and are expected to be fully operational by next year. By the use of curriculum committees, undergraduate degrees are individually formulated and can easily cut across departmental boundaries, with the claimed advantage of permitting more innovative study and research. There are approximately 900 undergraduate and 300 graduate students, of which surprisingly only 30 are doctoral candidates. The master's degree is seemingly becoming as popular in Israel as it is in the US, probably for much the same reason—a decrease in the funding support and the number of available positions for basic research in universities, government establishments, and private industry. The students are taught or supervised by some 54 senior faculty and 40 teaching assistants, a faculty-to-student ratio similar to that found in quality engineering schools in the US.

As an example of the kind of successful research engendered by the lack of rigid boundaries between disciplines, I was shown the results of an ongoing study on the measurement of the human foot/ground pressure pattern. The leader of the project is Prof. M. Arcan, who while in the Solid Mechanics, Materials, and Structures Department, has drawn heavily upon the resources and expertise of the bioengineering group. University researchers in the US are often reluctant to become involved in such interdisciplinary programs since tenure committees do not look kindly on such efforts if they do not lead to archival quality papers, a common fate for research that "falls within the cracks." This has not been a problem to date in Israeli universities, but as tenure becomes more difficult to obtain the situation could change.

The basic aim of the research program was to develop a reliable and quantitative technique for displaying and measuring the pressure distribution between the human foot and the ground. Previous methods using footprints in a plastic medium, load cells, or transducers gave only qualitative information, or only the value of total forces and center of pressure locations, or were encumbered by bulky cables or complex electronic equipment. The technique developed by Arcan and his colleagues is claimed to obviate these difficulties by using an optical interference method, as illustrated in Figure 1.

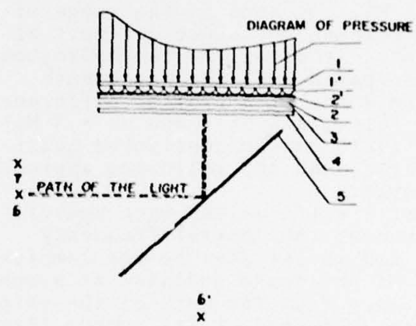


Figure 1. Schematic diagram of apparatus. (1) Flexible sheet with contact points to apply the pressure, (1') Contact points, (2) Optically sensitive (photoelastic) sheet, (2') Reflective layer, (3) Optical filter (polariser), (4) Sheet of rigid transparent material (glass), (5) Mirror or semimirror, (6 or 6') Possible positions of the light source, (7) Photographic or cinephoto equipment.

The apparatus consists of the following: A standing or walking platform, containing optical filters, optically sensitive elastic material, and a reflective layer; a light imaging and recording system composed of mirrors and a camera (for standing measurements) or a motion picture or TV system (for walking measurements); and a loading device, such as a thin leather sole on which are mounted a number of specially shaped solids used to provide discrete loading points. The number and shape of these loading centers

are determined by the accuracy of data required, as well as the particular stress distribution from the contact loading. The aim is that the loading be such that the contact forces acting upon the optical sandwich produce circular, sharply defined interference patterns, which are then directly imaged on a viewing screen. By the use of a calibration curve obtained employing known weights, the diameter of the interference circle then provides a direct measure of the normal force acting on the loading points. The local forces can be used to compute the average pressure on the area associated with each solid, and curve fitting procedures are then used to obtain the complete pressure distribution on the foot.

The applications foreseen and used for such a device are primarily for orthopedic diagnosis and subsequent monitoring of treatment. It has also been proposed for use in evaluating postural disorders from trauma (resulting from brain injury, lower limb fracture, etc.), and for evaluation of paralytic diseases.

Successful utilization of such a device requires establishing the basic load distribution for "normal" feet, at best a very subjective determination. Within such wide limits however, the foot/ground pressure pattern of an individual with an orthopedic problem can be compared to that of a subject with no visible deformation or pathological condition. Following this, for example, different orthopedic shoe inserts can be immediately evaluated and adjusted to yield a normal pattern. It is recognized by the developers that normality for one person's feet may not be that for another, but at least this approach provides an important first step. More successful use will require a systematic study of a statistically significant sampling separated by age, sex, weight, etc. If this technique gains wide acceptance, I expect that such a study will be forthcoming.

As an indication that capitalism is alive (and many hope flourishing) in socialist Israel, Arcan's development is now a patented instrument package available for general sale. Called "Footprint" it is being marketed through a university organization, the RAMOT University Authority for Applied Research and Industrial Development.
(I.M. Bernstein)

GENERAL

BRITISH ARCHITECTS, EDUCATION, AND THE PUBLIC

What is an architect? According to A Report on the Supply of Architects' Services with Reference to Scale Fees, presented to the British Parliament per Section 83 of the Fair Trading Act 1973 and ordered to be printed 8 November 1977, "...the architect, is a professional person who designs and inspects the erection of a building for a client... [as distinct from]...the builder who executes the work,..." It was not until the first part of the nineteenth century that there was a move to create the profession of architecture in England. Barrington Kaye in *The Development of the Architectural Profession in Britain* puts the move as "...the institutionalisation of an occupation based on a skilled intellectual technique, whereby the competence and integrity of practitioners are guaranteed to prospective purchasers of the services."

The Institute of British Architects was founded in 1834. It became the Royal Institute of British Architects (RIBA) in 1866, having been granted a Royal Charter in 1837. After 1882 all candidates for membership in the RIBA were required to pass an examination. This test was not introduced without argument. It was felt by many that the attributes required of an architect could not be measured by the usual written examinations. The first public, governmental registration occurred with the Architects Registration Act of 1931, which was followed by a loophole-plugging act in 1938. The two Acts, read together, "...require that everyone who practices or carries on business in the United Kingdom under any name, style or title containing the word 'Architect' (not including the designations 'naval architect', 'landscape architect' and 'golf-course architect') must have his name entered in a register." The register is kept by the Architects Registration Council of the United Kingdom (ARCUK), which recognizes proper qualifications for registration and also has the power to deregister in case of improper activities by a registrant. It should be noted that the Acts control only the

use of the title "architect." They do not prevent anyone from offering architectural services to the public so long as he is not described as an "architect." Moreover, there is no law requiring the consumer to hire an architect for such services.

Today the education of an architect in the UK is usually acquired through five years of university-level courses, i.e., a three-year BA plus a two-year BArch curriculum, followed by a two-year working internship under the supervision (and hire) of a registered practitioner. Codes of conduct for the "professional architect" are promulgated by both RIBA and ARCUK, the two codes being nearly identical. The codes are expressed, primarily in terms of the self-employed architect. Approximately 30% of the over 25,000 registered architects in the UK provide services on their own account, the balance are employees.

The early form of architectural education was the "pupillage" system, with night classes in technical institutes and art schools supplementing the daytime work experience of the student. The universities were then (and are still) considered socially and academically superior to the technical institutes and art schools. After the student acquired the education and training he sat for the RIBA examinations. Up to 1957 the pupillage system accounted for half the total students in the field. Formal (complete) courses at university-level institutions accounted for the other half.

At the 1958 Oxford Conference on Architectural Education, it was decided that all RIBA accredited courses should have an entry-level standard equal to that of the universities, and all recognized course programs should be located in universities or institutions of comparable standard. The recognition and acceptance of an academic program by the RIBA implies that the students who successfully complete the program are exempt from the RIBA examinations for those particular stages of education. By 1978 all courses were so located. One of the devices that accomplished this was the absorption of the technical institutes and art schools into new universities and polytechnics, all government controlled. There is only one school of architecture in the United Kingdom that is recognized by the RIBA and is not under government control, namely, the Architectural Association in Bedford Square, London.

The way British architectural education has developed has led to certain problems, upon which leading participants in its development have commented. Alex Gordon, a past president of the RIBA, in his address to the Darwin College Colloquium "Professors and Professionals" given in January 1978, commented on architectural curricula in institutions of higher education: "'Intellectual discipline' was interpreted as being superior to 'vocational training,' which in a sense it is; but as some schools began to take it as a substitute—although this was never the intention—there were serious consequences. Some of the polytechnic schools, in particular, in their eagerness to develop academic status, equated intellectual respectability with a departure from practicality.... Under the guise of liberal studies on intellectual advancement, courses have sometimes been dominated with activities on the fringe of, or beyond, the ultimate practice of architecture at the expense of essential knowledge and skills."

Gordon quotes the noted consulting engineer and architect Sir Ove Arup: "The architect was once a master builder. After he had ceased to be a builder himself, he was still master; he knew the art and craft of building, and he could design competently and tell the builder how the work should be done. But submerged by technology, he had to learn new tricks, he was bewildered, insecure. He had to listen to advice. He was still master, but he didn't master the technique of building any more. And a general who doesn't know his army, an artist who doesn't know his medium, and a designer who has to choose among unfamiliar materials and processes, is in an insecure position. He cannot design with confidence and he is in danger of losing the respect of those he commands." Gordon further quotes from the policy documents of one of the main political parties on construction: "At present education is controlled by the various professional institutions—architectural education, for instance, through the Board of Education of the Royal Institute of British Architects. Courses tend therefore to embody a narrowly professional approach, giving inadequate attention both to production aspects and to the wider social context of professional work. They rarely offer any practical

experience in the building industry, restrict entry to those with high-status academic qualifications, and give inadequate attention to the need, in an ever changing technical environment, for mid-career retraining. We therefore believe that education should be taken out of the hands of the professional institutions, and controlled instead by a body representing the interests of the industry as a whole, perhaps the Construction Industry Training Board." Gordon concluded his address by saying that, "Political parties, centres of learning and professional groups are all institutions, but in my opinion the last two have more in common. Politicians are primarily concerned with issues of the moment. Universities and professional institutions have always been concerned with longer term issues. They are inescapably necessary, increasingly complementary and dependent upon each other. Society will be ill served if the professors and the professionals cannot work together sufficiently to ensure that future educational policies are not set by politicians."

John Lloyd, now Consultant Head of the Department of Architecture at the Regional College of Art in Hull, UK, when installed (in 1967) as Principal of the Architectural Association, had other views: "Apart from the enormous expansion in education...another major trend...is toward individualisation and separate but interwoven with this, a trend towards breaking down the standard compartmentalised curriculum." He went on to compare it with what he saw as the virtues of American universities: "...individualism...has gone furtherest ...due to three factors: firstly that American education at university level is a mass based education as opposed to the elite based university education of Europe and Britain...secondly due to an underlying belief in the freedom of the individual and hence his freedom to choose his own course, and finally because of the belief that by allowing each person to follow his own course the greatest potential will be achieved within that person which will be to the eventual good of society."

Lloyd defined architecture as a problem-based problem-oriented profession. "Our prime task is to solve problems but not merely in a mechanical way...but in such a manner that the value content of the given situation is increased by the solution we adopt. This process is otherwise known as Design, and in our case is employed in the area of physical environment but has very important social implications."

He continued: "The past decade has seen an enormous increase in the awareness of the need for science and technology within the architectural profession. Whilst I fully acknowledge the contribution this has made..., I none the less re-affirm my belief that the primary task of the Architect is to design." Lloyd's view into the future produced this: "But now each of us and the profession as a whole has to decide the scale of activity where our major effort will be.... We must give up the life sapping nostalgia for other scales of activity than those we have chosen and the delusion of the universal man. I am convinced that if the profession is to make its contribution to society it must move its centre of effort into a larger scale than at present, and in such a way that the profession will increasingly control its own belief.... If this is done then one of the first casualties will be the artist craftsman.... In the same way we will have to give up the obsessional role of form giver, the creator of contemporary fetishes.... Our task of spatial organization will remain, but the role of coordinator and of solution programmer and synthesiser will clearly become of the greatest importance."

Barrie B. Steele, in a discussion paper given to the RIBA Education Committee in February 1977, gives a point of view of a professional who teaches. The comment that he makes is quite typical in both the UK and US. "In the nineteenth century there was no profession of quantity surveyors: they, and their younger brothers the building surveyors, sprang from our [architects'] loins. Town Planners have since bred; we are spawning Project Managers at the moment. We insist that the client should employ, and pay direct, other specialists too; structural and services engineers, interior designers, external landscapers, safety consultants, development advisors and the like. Not only have we relinquished control but we have actually proposed that it be passed to others."

The future of architecture, as with most professions, is clouded. The divisions of labor are changing. The opportunities for construction are at the moment still in decline. The need for construction still remains. In Great Britain, the profession feels that there are too many architects at the table,

let alone those just coming in the door. Those at the table cannot even agree on the menu. Some of those at the table do not feel that others at the table are still qualified to be there.

Since the early '70s the volume of construction handled by architects has declined significantly. The number of fledgling architects produced by the schools remains relatively constant, in fact there might be a few percentage points of rise. The main opportunity for expansion for architects in the UK is to export their services to the Third World.

While there is much anguish expressed over the scope of an architect's activities, there still remains the ever-present core of The Building. All standards focus on the ability to create that building. The criteria for evaluating these standards, attributes, and subjects of knowledge are, like the British Constitution, unwritten and will probably remain in that state. A critical question is: Who shapes the definition of the architect—the profession, or the public who consumes the services of the architect? Up till now the RIBA has, more or less successfully, defined the role. And in the main the RIBA also controls the criteria and standards used to evaluate the architect. It is only within recent memory that the Architects Registration Council of the United Kingdom has made moves to assert some authority in this area. As yet these moves are not significant. The press appears to be the only voice of the public that is effective in bringing the shortcomings of the profession to the attention of those who might take action. It is the descriptions of improprieties, the effects of faulty building, and the liabilities of the architect therefore that exert pressure for change. (Roger Orkin, Professor of Architecture, Syracuse University)

(Roger Orkin took a research leave in London extending from 1 January 1978 to 17 May in order to study the forces molding the architectural curriculum in the UK. On 15 May, a few days after completing this article, he suffered a heart attack and died while still in London. He was deeply interested in the teaching of architecture and had intended to carry out a similar investigation with regard to the US, then comparing the two approaches.)

AN EXCHANGE PROGRAM IN SWITZERLAND

During a recent visit to the Materials Department of the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, I had the opportunity of visiting a group of exchange students from Carnegie-Mellon University (C-MU). This innovative exchange program, now in its third year, involves juniors from various engineering and science departments at EPFL and C-MU who spend at least a year at the "foreign" university taking accredited degree courses. While approved by the administration of both schools, the programs are administered by an individual faculty member at each school, which perhaps explains the lack of bureaucracy associated with the program. With inevitable fickleness, a major complaint of the students is the lack of structure and direction, particularly in those difficult first hours when they found that the Swiss really intended to lecture in French and the Americans in American.

Currently there are six EPFL juniors at C-MU, plus four returnees from last year's group, while at Lausanne there are eight C-MU juniors, from the departments of mechanical, chemical, and electrical engineering, metallurgy and materials science, chemistry, and mathematics. The group consists of seven males and one female (from Math). There is very much a sense of a group spirit, in good part due to cultural and language isolation, which while diminishing is not expected to disappear entirely in the one year they are spending.

Students from both institutions are unanimous in their praise of the program, even after admitting the presence of minor irritants. There is the language problem I alluded to earlier, the coping with a new living environment, and the unfair comparisons of the geographical setting and scenery between Lausanne and Pittsburgh (I tried to soothe the anguish of the C-MU'ers longing for the breathtaking view of the Edgar Thompson works of US Steel on the banks of the beautiful Monongahela). These problems are more than compensated for by the quite different educational experience, the obvious travel benefits, and the confidence that comes from first surviving and then flourishing in an alien environment.

As most readers are aware, the philosophy, style, and goals of an undergraduate engineering or science education can vary considerably between US and European schools, and C-MU and EPFL are no exceptions to this. The European system devotes a considerable portion of its courses to fundamentals with emphasis on mathematical rigor and generally eschews the development of what might be called the conceptual skills associated with problem solving. In line with this approach, homework assignments are not extensive, there is emphasis on traditional and somewhat formal lecturing, and there can be a sizable absentee rate from classes as students tend to prepare for critical end-year exams on their own. I think it's fair to contrast the US system, as personified generally by C-MU, as one that uses fundamental skills as more of a framework to develop the analytical skills necessary to address and solve "real-world" problems. In addition, there is a greater tendency to monitor a student's progress closely by more frequent homework and quizzes. The C-MU students are of the general opinion that the more classical European system with emphasis on individual learning stems from the use of a much finer filter in the European admission process. Prospective students undergo a mind-stretching series of entrance exams with heavy emphasis on mathematical skills. A case can be made that with such an approach, admission becomes the major barrier to ultimate graduation; in the US there is a greater attrition rate in the later years as weaker students find themselves unable to cope with more advanced courses.

There is no way to judge which system is better or whether such a comparison has any meaning. Even with the differences, there is considerable commonality of purpose, and judging by the success of the exchange students, both groups are well prepared to flourish at either place. The true test of the success of any education system, of course, is how well its products (graduates) provide the technological and scientific skills needed by its society, and more importantly how well they can cope with new and unexpected areas. There is a required balance then between skill development and the ability to move beyond restrictive, specialized engineering and science applications. I will not even attempt to pass judgement on which of the above approaches does this better.

An interesting counterpoint to the more formal European system is the considerable autonomy given to students. Each class has a democratically elected representative who arbitrates, very often successfully, with the faculty on course and scheduling issues. One of the C-MU students likened this to collective bargaining, although in Switzerland it is a much more modest effort than, say Spain, where students have a direct vote for the choosing of University administrators, or Greece, where there has been a two-month student strike to increase the number of times they can retake year-end exams to avoid repeating the course (they wish to increase this from two to three times). Perhaps an increased interest in "democratization" will be something else the exchange students bring back to the US along with their slides, fluent French, and wonderful memories. (I.M. Bernstein)

NUCLEAR PUMPED LASERS

Nuclear pumped lasers are a new and somewhat controversial field of laser technology. The basic idea is to convert fission energy directly into laser light. Since 80% of the fission energy is invested as kinetic energy of the two fission fragments, it is hoped that these heavy ions (charge up to +22) will ionize the laser gas and the so formed energetic electrons will pump the laser gas. This is, so to speak, electron beam pumping via miniature electron beams, except that such beams need not be provided from the outside, but are generated by nuclear energy inside. Those familiar with nuclear criticality will immediately conclude that the power density deposited into the laser gas is limited only by the constraint that the device (reactor) has to stay intact. In other words, power density is determined only by the power removal rate. For a high-power laser man, this should sound like paradise. Nevertheless, the scientific community is not only cold about this idea, but for some reason, emotionally against it.

It was therefore very interesting to learn that an international conference would be held on this subject. It could be hoped that in such a forum, biases and political constraints would be absent, and one could get a clearer picture of what is behind nuclear pumping of lasers.

The "First International Symposium on Nuclear Induced Plasmas and Nuclear Pumped Lasers" was held from 23-25 May 1978 at the Laboratoire de Physique des Plasmas, Université de Paris-Sud, Orsay, France. Papers given pertained to nuclear pumping of lasers, the gaseous core reactor, measurement of lifetimes of atomic states excited by fission fragments, optical constants of uranium plasmas, excitation of gases by heavy ions from accelerators, and proton beam excitation of lasers. The countries represented by papers were the US, France, Germany, and the Netherlands. There were attendees from other European countries.

From the slides shown by Drs. K. Thom (NASA HQ), H.H. Helmick [Los Alamos Scientific Laboratory], and F. Hohl (NASA, Langley), one can gauge the applications NASA envisions for nuclear pumped lasers. These are long range communication, energy transfer to space probes, or even laser propulsion of space vehicles. For the last purpose, a compact gaseous core reactor is envisioned as a space vehicle's power supply. Because the nuclear fuel is in a gaseous state, a suitable laser gas mixture can be added to it, thus the laser and reactor would be one integral unit. For this reason, development of the gas core reactor is of interest to the nuclear laser people. A review of the status of this development was given by Helmick. There is, at present, a beryllium-reflected gaseous core reactor located at Los Alamos Scientific Laboratory, that is operating at low temperature and is undergoing reactor physics experiments. The fuel handling system was supplied by United Technologies and was described in two papers given by J.S. Kendal and W.C. Roman, respectively.

The bulk of the US nuclear pumped laser work is being done by NASA Langley Research Center, Los Alamos Scientific Laboratory, University of Illinois, University of Florida, Sandia Laboratories, and North Carolina State University (the order is arbitrary). Newcomers are Miami University of Ohio; Auburn University, Alabama; and the Advanced Technology Center, Huntsville, Alabama. In the European countries, efforts in nuclear pumping are located at the Universität of Stuttgart; Université Paris-Sud, Orsay; and the Université d'Orleans. An effort in gaseous core reactors exists at the FOM-Institute for Atomic and Molecular Physics, Amsterdam.

Judging from the presentations given, it can be said the whole field is still in its infancy. However, it seems to be growing fast. The state-of-the-art is that for all noble gases, nuclear pumping has been demonstrated employing fast burst reactors. Also, CO has been pumped, and nuclear augumentation has been demonstrated for CH_3I (JPL and LASL). Some old experiments (early 1971) carried out at the University of Florida demonstrated nuclear augmentation of CO_2 (CW). (Nuclear augmentation means that only a fraction of the laser energy comes from nuclear energy while the rest comes from conventional sources.) All burst reactors deliver a very high neutron flux (10^{17} n/cm^{2}sec and more) for a short time (100 μsec). Therefore, the lasers excited with these reactors appear to be pulsed lasers, but they are really not, at least not in the sense of pulsed lasers of regular laser technology. They are, indeed, CW lasers that cease lasing action because the source of excitation is ceasing operation. From the results of all these previous experiments, it was believed that nuclear pumped lasers require a threshold neutron flux of about 1×10^{15} n/cm^{2}sec. A paper given by B.D. Carter (University of Florida) showed that this is not the case. He reported on a CW (hours) nuclear-pumped laser experiment involving He-Ne that required a threshold of only 1×10^{12} n/cm^{2}sec. This new result confirms that nuclear-pumped laser-reactors could be based on existing reactor technology.

What has to happen next? In order to overcome the scepticism of the laser community, the next step has to demonstrate that a high-power nuclear-pumped laser is feasible. This must be a CW or repetitively pulsed laser of high repetition rate, so that an average power of—say at least 5 W—can be delivered for an extended time period (minutes or hours). There will still be a long way to go to the required kilowatts or even megawatts, but it will be sufficient to interest enough people to work in the field so it can become a viable discipline of laser technology. (R.T. Schneider, Univ. of Florida, Dept. of Nuclear Engineering Sciences, Gainesville, FL)

NOW DON'T GET RATTLED.......

During the fall of 1976 and thereafter noises, heard mostly indoors, were reported in the southwestern part of England. The overwhelming majority of these reports noted that the noises occurred about nine o'clock in the evening on most nights of the week. Since the noises resembled in some respects those of a thunderstorm at a distance or possibly an explosion, an attempt was made to correlate them with any explosions taking place in the area, or thunderstorms. However, the regularity of the noises over a wide area began to raise concern that they might be man-made or man-timetabled, and might be very loud at their point of origin.

On 16 November 1976 at the invitation of Dr. D. Tanner of the Western Daily Press, Mr. T.V. Lawson of the Univ. of Bristol's Dept. of Aeronautical Engineering began investigating this phenomenon. Lawson went to North Petherton in Somerset where the phenomenon had been reported, and he indeed heard a distant rumble. In fact, he heard a series of three rumbles with time separations of 20 and 10 seconds, the middle one being slightly louder than the other two. Curiously, the sound was much more obvious indoors than outside, a fact attributed later to its low-frequency characteristics which tend to rattle window panes. Lawson was joined in this investigation by his colleagues at Bristol, Dr. R.D. Adams of the Dept. of Mechanical Engineering and Dr. P.S. Applin of the Dept. of Physics. Measurements conducted, indicated that no ground motion was involved, although a very definite sonic disturbance was recorded. After an announcement on television and a call for the cooperation of the public, some 500 replies were received. An important input to these public reports was the precision of some of the time information as Lawson had asked observers to check the time against the Post Office Telephone System's time signals. Describing in detail the occurrence of the noises, the reports when taken together indicated a pattern progressing with time over southern England.

It was then that Concorde became suspect as the source, although its supersonic flight paths in the middle of the English Channel are designated so as to assure that the direct sonic boom does not reach the coast.

The structure of the atmosphere is such that its temperature decreases from sea level up to an altitude of 11 km. From 11 km to 20 km the temperature is isothermal. From 20 km to 50 km the temperature increases, and above that it decreases again up to an altitude of 80 km. Above about 100 km the temperature again begins to increase rapidly in a region called the thermosphere. This temperature structure is the primary factor determining the sound speed profile in the atmosphere as the effects of pressure are compensated by equivalent density changes. Taken with the wind profile it determines how sound is propagated through the atmosphere and can result in sound radiated into the atmosphere being returned to the earth. Atmospheric refraction and the properties of an aircraft source (speed, mach number, height, etc.) determine the area on the ground which will be irradiated by refracted sound from the vehicle. This area can be substantially larger than the "primary carpet" irradiated directly. Within this larger area separate "carpets" moving with the aircraft can be identified as associated with "reflection" from each of the regions of increasing atmospheric temperature, and with sound leaving the aircraft in an upward and downward direction. These overlapping "carpets" of sound impingement may be identified by the different arrival times associated with their various sound paths. They may be further multiplied by additional reflections from the ground for each type of path.

Ray tracing techniques have been used to delineate the various "carpets" for a variety of atmospheric conditions including wind shear (which varies with the season), and for various aircraft operating conditions, and then correlated with observer reports and Concorde operations. In this work of resolving the nature of the observed signals the Bristol group have received ready assistance from Bristol Aerospace, from British Airways on Concorde operating schedules and operations, and from the UK's Department of Trade and Industry. Not all of the noise reports have been tied to Concorde, for some events occur at times which cannot be correlated with Concorde flights. These extraneous noises may have other possible sources such as gunnery practice, quarry blasting and the like, and military supersonic aircraft.

We should emphasize that the signals have been of low intensity and probably were only observed in the first instance because of a combination of a very quiet rural background, and their occurrence on a well-defined schedule, tied to a period when UK residents habitually listen to the BBC's 9 pm News. Highest levels observed that could be correlated with Concorde have not exceeded about 1 Pa (1 N/m^2), and more usually levels have been less than 0.2 Pa.

Notably the signals observed are not direct observations of the primary shockwave from the supersonic aircraft, although they arise from it. The aircraft does not move at supersonic speed over the point where the sounds are observed. However, when the aircraft is moving supersonically over the sea, its shock wave effects may be noted some 100 miles away over the land as a result of refraction in the atmosphere.

Some curious effects have been reported relative to these signals. For example, on a number of occasions, it has been observed that pheasants seem to have sensed a signal perhaps 30 seconds before its human observation. Since most of the sound is below 5 Hz it is inaudible to humans but could perhaps be sensed by birds through the vibrations of the branches upon which they were roosting. Such an explanation would still leave as issues the time delay and the transmission path. Studies with a limited number of experienced observers are continuing.
(Martin Lessen and Aubrey W. Pryce)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

MATERIAL SCIENCES

PIEZOELECTRICITY OF PVF_2 FILMS—IS IT AN INTERFACE EFFECT?

Loyal readers of *ESN* will certainly know by now that the Max-Planck-Institutes form an important element in the fabric of West German research. They are supported primarily by funds that come through the Federal Government, but 20% of their support also comes from private funds and endowments. Altogether there are 50 institutes, research units, and project groups supported by the parent organization. About 24% of the governmental research funding goes to these laboratories. They do not teach but have a large number of students from universities and guests from abroad who use the specialized facilities of the institutes. Universities obtain their funding primarily from the West German state in which they are located. For instance, the University of Stuttgart is supported by Swabia. As a result there is no direct competition for funds between universities and the Max-Planck-Institutes. Nevertheless, it seemed to me that there exists a vigorous and healthy competition for scientific prestige.

In Stuttgart, the two institutions seem to face each other in the discipline of solid state physics and in real space as well. An earlier note (*ESN* 32-4) has described the special concentration of solid state research effort in the University of Stuttgart. The new University buildings look out over a half mile of farmland to the equally new buildings of the Max-Planck-Institutb for Research in Solids. This Institute has a staff of 200 of whom 68 are scientists. The work of the Institute covers chemistry, physics, and theory. It tends to avoid research in metals since there is another Max-Planck-Institute devoted to those materials. Direction of the work of the Institute falls to ten senior scientists each of whom has a nearly independent research program that he administers.

One of the Directors at this Institute is Professor K. Dransfeld whose interests involve such diverse activities as ultrasonics, high magnetic fields, and the structure of glasses. I want

to report here on one facet of his work: the piezoelectricity of polyvinylidene fluoride (PVF_2).

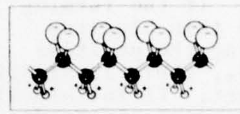
Piezoelectricity has gone through a series of developments since its discovery. Early studies concentrated on single crystals such as quartz which still are widely used for controlling the frequency of radio oscillators and are finding new applications now in electronic watches.

Ferroelectric crystals and ceramics began to appear about four decades ago. These materials have an electric dipole moment even without the application of an external electric field. Pressure can change the field, or an applied field can change dimensions of the solid so that these materials are also piezoelectric. In the same way, the polarization may change with temperature so that the materials are used also in pyroelectric applications. Large sonar acoustic sources are frequently made of ferroelectric ceramics—often mixtures of titanates. Sensitive pyroelectrics are commonly made from tri-glycine sulfate (TGS).

Recently it has been found that a new class of piezoelectric materials exists in the form of organic polymers. This development followed from the work of Fukada, who looked at a variety of biological materials and found that even bone and tendon developed surface charges when stressed. Development moved rapidly in this area, and now PVF_2 is emerging as the most promising of the organic materials. It is already being used in piezoelectric loudspeakers and fast pyroelectric detectors; its flexibility and light weight for large area are arguments for developing it as detectors in hydrophone arrays. When used in thin films, PVF_2 can produce high-frequency acoustic waves; experiments at frequencies as high as 9 GHz have been reported. In pyroelectric detectors, response at 1 nsec has been seen.

To form a piezoelectric film of PVF_2, the film is normally aluminized on both sides and heated to about 100°C for an hour with an electric field of about 5×10^5 V/cm applied. The film is allowed to cool to room temperature with the field still applied. Upon removal of the field the film is now seen to be piezoelectric.

For all of the technological development, however, the basic mechanisms at work in the material are obscure. In a normal industrial PVF_2 material, the films have been found to be 65% crystalline as seen by small angle x-ray scattering. Of the crystalline phase, 90% is in the nonpolar α-form, and 10% is in the polar β-form. At the atomic level the monomer consists of CH_2CF_2. The figure illustrates the atomic arrangement in PVF_2. Due to the strong electro-



negativity of the fluorine atom, the PVF_2-chain posesses a strong dipole moment normal to the chain axis. In the α-form the crystal has no electric dipole moment; however, there is a moment for the β-form. Nothing is known about the effect of defects in the polymer chain or of the influence of ionic impurities.

Most of the explanations that have been proposed derive from the experience with inorganic materials. It is argued that in the high-temperature forming process, dipoles or domains are oriented throughout the film and that the origin of the effect is in the β crystals. However, PVF_2 samples with only α crystals and noncrystalline material have been produced. These samples also show piezoelectricity. These results seem to indicate that the processes leading to piezoelectricity in PVF_2 are not easily identifiable with those in inorganic solids.

In recent work H. Sussner and Dransfeld have demonstrated quite convincingly that the piezoelectric effect in PVF_2 is not an intrinsic bulk property of the polymer but is influenced by the positive electrode. Two different experiments lead to this conclusion. In one experiment a piezoelectric PVF_2 film was freely suspended as a flat plate and driven by ac frequencies from 0 to 100 MHz. The first thickness resonance was observed at 22 MHz and corresponds to a film thickness of $\lambda/2$ as expected. All textbooks on acoustics show that a freely suspended homogeneous piezoelectric plate can be excited at frequencies where the plate thickness corresponds to

$\lambda/2,\ 3\lambda/2,\ 5\lambda/2$ ----.

In general, vibrations at λ, 2λ, --- cannot be excited piezoelectrically.

Sussner and Dransfeld found, however, that their PVF_2 film had an even stronger resonance when the film had a thickness of λ than for $\lambda/2$! The conclusion is that piezoelectricity is not homogeneous in PVF_2.

The other experiments have to do with the actual contact of the positive electrode on the film. If the forming process is done with a thin blocking layer of SiO_2 separating the positive electrode from the PVF_2, there is hardly any piezoelectric effect. If the blocking layer is put at the negative electrode instead, the performance is normal. Similarly, three layers of PVF_2 were placed on top of each other and electrodes were added at the top and bottom of the stack. After the normal forming procedure, the films were tested individually. Only the film that had contacted the positive electrode showed a normal piezoelectric response. The other films had responses reduced by factors of 10 or more.

These experiments argue very forcefully that the metal-polymer interface is critical for the development of strong piezoelectricity in PVF_2 and that it does not arise from the bulk properties of the polymer.

That seems to be where the mystery lies at the moment. One might think the problem now would be one that the host of clever surface study tools would quickly unravel—and they may. However, the PVF_2 film presents a complex amorphous and crystalline surface, and the various possibilities of diffusion, reorientation, conduction, chemical reaction, and charge injection in crystal and amorphous polymers contacting a metallic electrode may not yield a full understanding very easily. The work of Sussner and Dransfeld has served to emphasize the critical importance of interface rather than bulk properties of the PVF_2 polymer. (Clifford C. Klick)

MATERIALS SELECTION MADE EASIER

The Fulmer Research Institute Limited, located in a beautiful, somewhat idyllic setting in Stoke Poges, Buckinghamshire (less than 30 minutes by train from London) is likely the largest non-profit research organization in the United Kingdom. Under the unusual ownership of a professional body of scientists, the Institute of Physics, Fulmer has continued its growth even during these difficult times for research. Following the recent merger with Yarsley Ltd., it has greatly expanded its research and testing capability to cover the whole range of materials from metals to ceramics to polymers. A fuller description of Fulmer's background and activities can be found in ONRL report R-63-70. The Fulmer Research Institute by E.I. Salkovitz (AD-873349)

During a recent visit I learned about a new activity designed to help solve the complex and often impossible problem of selecting the proper material and processing conditions for a specific product. This is the development of the Fulmer Materials Optimizer which is claimed to be a new information system for the selection and specification of engineering materials. The formidable task of producing the Optimizer (as it is called) involved the skills of 25 materials specialists for more than 2 years,, under the supervision and direction of Dr. Norman Waterman, Group Manager, Marketing and Information. He conceived the idea of such a compilation of data while working in Denmark, then moved to Fulmer which provides the ideal setting for implementing the production of such a document. As those of us who have been engaged in similar activities know, the stage between the idea and the final product is much longer and much more painful than originally envisaged. This undertaking was no exception. Satisfaction upon completing such an endeavor is, of course, very dependent on its acceptability among product designers and materials specifiers, and most critically in the market place. To date both appear to be forthcoming, and Waterman is quite optimistic of the long-term future and worth of the Optimizer.

Any compilation of data with attendant analyses has at the very least three major drawbacks:

1) New materials, products, and specifications could quickly make it obsolete.

2) New applications place undesigned-for constraints on material properties; without the proper interactive data not enough parameters exist for the systemized decision approach specified in the Optimizer.

3) The concept, the document, and the philosophy must be acceptable to the design community.

These and other constraints have been recognized, at least in principle. How

they are being handled should become clearer as I describe the Optimizer Handbook's contents.

The data and design approach for its utilization described in the Optimizer were obtained by a claimed critical evaluation of the vast quantity of information in trade and scientific journals, and from Fulmer's own sources. These inputs were further analyzed and filtered in consultation with a number of experts in the materials supply and processing industries. The end-product of the deliberations is in four volumes as follows: Volume I—Comparison of Materials; Volume II—Characterization and Specification of Metals; Volume III—Characterization and Specifications of Non-Metals; Volume IV—Materials Selection System and Examples. The problem of information perishability has been addressed by printing the Optimizer in a loose-leaf form to allow rapid updating of the system. Subscribers receive, in addition to the basic system, a complete yearly review of materials costs, data refinement as it becomes available, information on new materials and processes, and case histories of new applications of existing materials.

In addition to its repository role, the Optimizer sets out guidelines for product selection in terms of the desirable characteristics of material availability, ease of processing, acceptable mechanical and physical properties for the final product, and, most importantly to manufacturers, an adequate quality level at an acceptable cost. These broad-ranged specifications, of necessity, lead to tradeoffs between cost and quality in most engineering products, and this compromise is also considered, if not explicitly then implicitly. The information system has been further designed to permit such product selection both for the case of specifying materials and manufacturing routes of a new product and for the evaluation of alternative materials and routes of an existing product.

A methodology for these materials-related decisions is presented as a flow chart of increasing detail in which the product function and processing steps are evaluated by maximizing the summation function $\Sigma_i M_i W_i/C$, where a given M_i is an identified required material characteristic, W_i is a weighting factor assigned to each characteristic according to function importance, and C is the approximate total manufacturing cost for each material. While such a procedural approach can be readily computerized, this has not yet been done.

How well does such a system work? I think the answer must be—as well as can be expected. The procedure is clearly much preferred over the more prevalent one of designing a part based on handbook values (often using not even the relevant properties) and on that famous catch-all phrase "seasoned experience." While the Optimizer goes clearly beyond this and recognizes the spectrum of properties that must be considered and weighted, I foresee dangers if this approach is taken too literally. For example, consider one of their illustrative case histories, a pumping device for fluids. Even for the rather prosaic application of say a metering pump for vending machines, at least the following properties would have to be known, weighted, and optimized:

Mechanical properties such as strength, stiffness, fatigue resistance, and their temperature dependence; corrosion susceptibility and protection; wear resistance and frictional properties; physical properties such as thermal and electrical conductivity, magnetic susceptibility, damping capacity, formability, and component manufacturing methods; and direct costs attributable to the chosen material and manufacturing route.

The mere fact that there are interactive properties to be considered, as for example the ability of a corrosive media to modify mechanical properties, means that a manufacturer must carry out careful proof testing and not simply and blindly rely on the Optimizer as an absolute predictor. Indeed, Fulmer recognizes this by cautioning users to consider the specific application of the materials or processing schedules and to be cognizant of unknown constraints associated with their perhaps unique application. If these warnings are heeded, these volumes should make an important contribution to materials selection procedures. (I.M. Bernstein)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

MATHEMATICAL SCIENCES

A GLIMPSE AT THE PROBLEMS OF (MATHEMATICS) EDUCATION IN THIRD WORLD COUNTRIES

Khartoum, Sudan was the setting for a major worldwide conference on the topic "Developing Mathematics in Third World Countries." The meeting, which was held 6-10 March, was organized by Dr. Mohamed E.A. El Tom and other members of the Department of Mathematics of the University of Khartoum and attracted more than 150 delegates from 41 countries. Although the embryonic African Mathematical Union and the US Army Research Office provided some financial support, the Univ. of Khartoum was the principal sponsor.

The vast majority of the delegates were mathematicians, educators, or representatives of educational ministries from the underdeveloped nations of Africa, Central and South America, and the Middle and Far East. Even among the delegates from the industrially advanced countries such as the US (7), Canada (3), France (6), Sweden (1), and the UK (11), most were either expatriates of Third World countries or Western mathematicians with prior personal experience and understanding of the unique problems faced by such nations.

The meeting was held in the Khartoum Hilton, an island of American comfort and extravagance in the midst of the most abject national poverty I personally have ever seen. With the Sudanese pound pegged artificially at exactly $2.50, the week's hotel bill came to more than the average annual income of the Sudanese peasant.

Although Khartoum may seem a strange setting for a worldwide conference, it seems much less so when one considers the geographical distribution of the nonaligned, underdeveloped nations of the world. From this perspective, Khartoum is actually an appropriate location for a meeting of representatives from Third World nations. Moreover, the problems faced by most developing Third World countries are patently and pathetically evident in Sudan, and Khartoum is not the kind of "fun city" in which one is tempted to skip away from the meeting to wander about on one's own!

With a land area of 968 thousand square miles, Sudan is the largest of the present 43 African nations—twice the size of the nine countries that comprise the European Common Market. Some other Sudanese statistics: Nearly 50% of the population is under 15 years of age; adult literacy is estimated to be about 15%; there is one doctor for every 11,000 people and one hospital bed for every 1,000; per capita income is less than $300 per year. While it may not be the poorest country in the world (or it may be, depending upon how one measures such things), it is clearly desperately impoverished. And yet, the two or three "acceptable" (to a Westerner) hotels in Khartoum are constantly booked to overflowing by American, French, German, British, and other businessmen who are anxious to help the Sudanese accomplish some of their grandiose development goals.

Although Arabic is the official language, Sudan is *neither an Arab state* nor a black African nation. Rather, as the *Economist* (March 18, 1978) described it, "Sudan is *sui generis*, and happy to remain so, a bridge between Africa and Arabia. It is the Arab connection which lies at the heart of all Sudan's ambitious plans." The point is that 80% of the Arab world's cultivable land is thought to be in Sudan, and the oil-producing Arab countries feel quite uncomfortable about being as heavily reliant upon the West for food as the West is upon them for oil. So, under a $6.5 billion agricultural development scheme drawn up by the Arab Authority for Development and Agricultural Investment, Sudan's goal is to be able to meet 40% of the Arabs' food needs by 1985. In brief, that's the reason for the overflowing hotels in Khartoum.

The scientific program consisted of 16 invited and 24 contributed presentations, all of which were delivered during the first day of the Conference. Of these 40 talks, only two were delivered in the opening general session—the remaining papers were presented in four parallel sessions extending to beyond

8:00 pm. The reason for this seemingly odd compression of all formal presentations into the first day of the meeting was to allow ample time (i.e., the following three days) for concentrated "Working Group" discussions of what the organizers perceived as four distinct aspects of mathematics education and scholarship as they relate to the social conditions and the needs of Third World countries: 1. School Mathematics (i.e., elementary and secondary education), 2. University Mathematics Institutions, 3. Mathematics and Development, and 4. Mathematics Policy and International Cooperation.

In the following, I will not attempt to review any of the individual papers which were presented, but rather to relate some of the key issues discussed at the Conference.

In connection with School Mathematics, there was general agreement among the delegates that the vast majority of children at present and for the foreseeable future receive, at most, six years of primary education; a very small, but potentially influential and powerful, minority of children are in some way selected to receive education beyond the primary level. It was also agreed that, due to horribly overcrowded classrooms, the lack of facilities and supplies, and the general conditions under which teachers must work, their sense of dedication and morale is generally very low.

There was a great deal of discussion regarding "traditional" mathematics versus the so-called "new" mathematics. Most delegates felt quite strongly that the "new" mathematics, which is widely regarded as being of questionable value for the vast majority of students in even the most industrially advanced countries, is totally inappropriate in Third World primary and secondary schools. The American Peace Corps was repeatedly faulted by various delegates for having introduced "new" mathematics cirricula into underdeveloped countries more than a decade ago. The French, who are today the principal advocates of abstract, formalistic mathematics at the elementary and secondary levels, were also heavily criticized for fostering "new math" programs in their former colonies. Another point, made repeatedly, was that textbooks written for children of an industrialized Western culture presume a social and cultural ambiance that is totally foreign to children of underdeveloped countries.

It was almost unanimously agreed that the successful teaching of a practical working knowledge of basic mathematical skills requires that arithmetic and algebraic concepts be taught principally by induction, with the aid of many illustrative examples taken from the local culture. For instance, the concept of addition should be illustrated by asking how many head of cattle are there in total if a herd of 60 is combined with another herd of 40, rather than—as one finds in the jargon of the "new math"—asking the cardinality of the union of two sets whose cardinalities are 60 and 40. It must, however, be said that there was a small but very vocal group of "new math" advocates. Most of these proponents were articulate Western pedants who, to this observer, seemed oblivious to any cultural differences between Western civilization and the societies of the Third World nations.

The main points of concern addressed by both the Working Group on University Mathematics Institutions and the Group on Mathematics and Development were surprisingly similar to the concerns which the author has heard so many times discussed in the American mathematics community. Namely: To what extent should university mathematics programs emphasize applied as opposed to pure mathematics? What is the proper relationship between mathematics departments and other technical and scientific departments within the University? How can a mathematics department develop and maintain internationally accepted standards of mathematical scholarship, and is the cultivation of mathematical scholarship *per se* (e.g., publishable research papers) an appropriate objective of Third World mathematicians, or, should they simply be content with the teaching of mathematics, i.e., is the cultivation of research expertise an extravagance which should be foregone in an impoverished country? These are typical of the issues which Working Groups 2 and 3 discussed *ad nauseum* for three days. Needless to say, no definitive answers were agreed upon. The discussions were, nevertheless, often interesting and enlightening.

The sessions that I personally found most intriguing were the meetings of the Group concerned with Mathematics Policy and International Cooperation. One of the main issues discussed was the problem of training PhD and postdoc-

toral level mathematicians who are citizens of Third World nations. Every delegate present agreed that, while the employment of foreign technical experts is a necessary expedient for the present, in the longer run each country must develop its own professional and technical capabilities through the education of its best qualified youth. (To be totally reliant upon foreign powers for scientific and technical expertise is clearly recognized as a precarious national policy.) To do so, however, normally entails advanced level training abroad since the countries themselves do not have the technological base required for doctoral and postdoctoral training. Of course, this has always been true and, as we all know, many underdeveloped countries have traditionally sent their best students to Europe and the US for advanced study. The problem which all too often develops is that the individuals who go abroad never return to their native country because of the comparative comfort, affluence, and career opportunities that they find elsewhere. The most practical solution proposed to guarantee the return of students studying abroad is to send only those who have reached an advanced level of training within their own country and who have a strongly vested interest in returning, e.g., students who are married and have binding family responsibilities.

Perhaps the most concrete and viable proposal to emerge from this Working Group was the suggestion that an International Center of Pure and Applied Mathematics be established in response to the needs of Third World countries. It is envisioned that the senior staff of the Center would be comprised of world-renowned mathematicians on one- or two year visiting appointments. The functions of the Center would include advanced level education and the provision of research facilities for the continuous assistance in the development of mathematics in Third World countries. The Working Group also recommended the creation of Regional Centers to complement the activities of the International Center, e.g., Regional Centers in Africa, South America, and the Far East. Some of the conference delegates obviously have close ties with UNESCO and, although the political mechanisms were unclear, one was left with the impression that these recommendations would be presented formally to UNESCO.

The Khartoum Conference was entitled "Developing Mathematics in Third World Countries." However, the problems of developing mathematics education programs are, by and large, not specific to mathematics but rather to the conditions of poverty and lack of educational resources in the nations of the Third World. How nations without long-established educational traditions and institutions can educate a significant fraction of their children and young people to anything approaching the educational levels of the developed nations is a very perplexing question. Except for countries like Saudi Arabia which can afford to pour vast amounts of money into the effort, it is difficult to see how, in the next generation or two, the really impoverished nations will be able to achieve the goal of educational self-sufficiency. As one delegate from Mexico pointed out, although the educational and technological level in Mexico continues to improve year by year, the gap between the US and Mexico also increases year by year and there is no hope of ever catching up with American science and technology.

At one point in the lengthy discussions, one of the members of the faculty of the Univ. of Khartoum politely interrupted the long-winded, idealistic, and ever-so-erudite ramblings of a mathematics educator to suggest that the gentleman might better understand the real problems of elementary school education in Sudan if he were to visit one of the local village schools—the point of the suggestion being that conditions in the Third World are far beyond the imagination of Westerners who haven't seen them. (William J. Gordon)

PHYSICAL SCIENCES

OPTICS AT THE ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

The Royal Armament Research and Development Establishment (RARDE) Fort Halstead, Sevenoaks, Kent operates within the UK Ministry of Defence (MOD). Its

main function is to assess and develop conventional weapons systems for the three armed services.

The Optics Branch, under the direction of Dr. Nigel D. Haig, is responsible for a wide variety of optical services related to military applications over the spectral range from the visible to the far infrared. Their work includes surveillance devices, laser applications such as rangefinders and target designators, gun sights, infrared imaging systems, and holography.

This Branch appears to be unique among military optical groups in that their capability encompasses all phases of optical device development. For example, the basic conceptual design, optical element design, prototype construction including lens grinding and optical coating, and evaluation are all carried out by the one group. Additionally they have the capability to consider human behavior and physiology as well as ease of manufacture in the design of a device.

The optical design work is carried out by Mr. E.J. Russelle and Dr. D.R.J. Campbell. They use computer techniques to optimize lens design by calculating the diffraction optical transfer function (OTF). This method currently takes a few hours; however, they are getting a V77 Varian computer which should decrease the time by a factor of 100.

They do more than straight lens design, however. Unlike many lens designers this group is attempting to develop additional practical features in the design program such as cost of manufacture, sensible tolerances, use of materials capable of withstanding rough use, and ease of use in the field.

The Systems Studies and Visual Optics Research Section of the Optics Branch is devoted to the premise that there is usually a man at one end of an optical system, and the physiology and behavior of the user cannot be ignored when considering the performance of an optical system. Drs. R. Home and G.J. Burton, who are principal scientists in this Section, described four lines of investigation that they are pursuing. The first of the four is completed, and the others are in progress.

1. The collimation of binocular instruments has been based on the assumption that the observer accommodates to a focus at infinity. Binocular instruments built on this assumption had their limbs parallel. Research in recent years, however, shows that normal accommodation is actually at about one meter. If this is so, then the limbs of a binocular instrument should be angled slightly. In one of their publications on this topic (*SPIE* Vol. 98, "Assessment of Imaging Systems," Sira, Nov. 1976, London) they found that taking the normal accommodation distance into account improves contrast sensitivity by 20%. This modification will be considered in the future production of binoculars for the British Army.

2. Home and Burton contend that no good techniques exist to measure glare. An instrument, otherwise optically perfect, can be useless if glare is high. This project concentrates on measurements of glare that optical designers can use, not methods for eliminating glare.

3. Cathode-ray tubes are used for imaging in many systems, and they have variables that affect the quality of the image, such as noise. These effects will be studied.

4. Transfer functions for physical optical systems give the transformation from input to output, but this does not consider the transformations that the human user of the optical system introduces. Home and Burton plan to investigate transformations of optical systems with the human involved. This approach is similar to those that have been made with continuous control systems (trackers). An engineer can calculate the transfer function for a control system, but the function is not the same when the human is in the loop.

According to Haig, his Branch has the best facility for examining ir optics in the UK. Three different techniques are employed for assessing the performance of lenses operating in the 8- to 13-μm band. They are: Interferometry, pupil scanning, and determination of polychromatic line-spread function with a hot wire source and a PbSnTe line detector. Two interferometers are employed in the first method. One is a Twyman-Green system having an aperture of 50 mm and the other a reflecting optical system employing a diffraction grating beam-splitter having an aperture of 150 mm. Both interferometers are operated at 10.6 μm with a CO_2 laser source. Since ir fringes are not visible, a pyroelectric vidicon TV camera is used to observe the interferograms.

Transverse ray aberrations of ir lenses are obtained by a relatively simple but well-designed device which scans a single paraxial ray across the lens to be analyzed. Detectors determine the position of the input ray in the entrance aperture and the refracted ray at the focal plane (or elsewhere) as the input ray is scanned across the entrance aperture. From this data the aberration and the wavefront distortion can be calculated.

The third technique uses a 25-μm diameter nichrome wire, typically operating at 20°C above ambient temperature, as a line source to obtain the line spread function (LSF) for ir lenses. A 20-μm × 3-mm PbSnTe line detector is stepped across the image plane to obtain the LSF. Or alternatively, the source can be scanned across the object plane. A Fourier transform microprocessor is used to calculate the modulation transfer function (MTF).

The Branch has an optical shop and a machine shop where visible and ir lenses and reflecting optical systems including multilayer coatings are made. This is a tremendous advantage over having to contract out prototype optical devices.

The Optics Branch at RARDE is a good group of diversified people that provide a very worthwhile capability to MOD. The fact that the human element and manufacturing difficulties are considered by the same group that designs the lenses should result in faster and less costly development of military devices. (Vern N. Smiley and Jack A. Adams)

PSYCHOLOGICAL SCIENCES

A BIG LEAP FORWARD FOR COMPUTER BASED LEARNING IN THE UK

A meeting was held on 14 March 1978 at The Institution of Electrical Engineers (Savoy Place, London) to hear a report on a national five-year program on computer based learning which ended in December 1977. The name of the program was "National Development Programme in Computer Assisted Learning," and the agency in charge was the Council for Educational Technology (3 Devonshire Street, London). Mr. Richard Hooper was director of the program. The aim of the program was "institutionalization," which meant the establishment of computer-based learning on a permanent basis in educational institutions across the country. The program gave matching funds to an institution willing to pay part of the costs, which was usually payment in the form of computer facilities and personnel time. Almost 5 million US dollars of UK government money was spent on 27 projects in 44 institutions, ranging from universities and secondary schools to the training of technicians in the military and the Post Office. Institutionalization was achieved in 70% of the cases.

The program staff made the distinction between computer assisted instruction, computer assisted learning, and computer managed learning. Computer assisted instruction, which was identified with developments on the American scene, means that a computerized teaching machine replaces the teacher and provides full individualized instruction. Computer assisted learning uses the computer as a classroom aid, such as an instructional film or a piece of laboratory equipment. On an individual basis, the computer may serve as a tutor and provide exercises and facts, or be an agent for laboratory learning as a tool for calculation, simulation, and problem-solving. Computer managed learning is on the periphery of the learning process. The computer is a manager. Records are kept, tests are given, scored, and analyzed, and students are routed through course modules on the basis of learning ability.

The program rejected computer assisted instruction and came down firm on the side of computer assisted learning and computer managed learning. In the 1960s, advocates of computer assisted instruction promised an electronic revolution in the classroom, with teachers being replaced by the computer and the quality of teaching becoming higher than ever, but the revolution never took place. The program staff found the routes of computer assisted learning and computer managed learning more congenial, perhaps for reasons of costs, perhaps to avoid the sensitive issue of the replacement of teachers with machines, or very likely for the reason of no decisive evidence that computer assisted instruction is better than human instruction.

What were some of the projects like? A successful one was CALCHEM (Computer Assisted Learning in Chemistry): About 40 packages of computer programs and adjunct materials were developed to study

factors in the design of laboratory experiments, the interpretation of spectra, the solution of theoretical problems, and the evaluation of experimental data. By 1977 the project involved 20 institutions, 100 chemistry teachers, and 2200 students. The Department of Medicine at the University of Glasgow, gave their students exercises in clinical decision making. Remedial reading was taught in the schools of the County of South Glamorgan. The Royal Air Force at Locking used the computer to assist the planning and scheduling of programs in a radio school. The Post Office gave maintenance training to telecommunications technicians.

What does computer assisted learning cost? The cost accounting of educational processes is difficult, but analysts nevertheless concluded that computer assisted learning is expensive to develop and to keep around as part of the educational system. Many of the packages developed were labor intensive, requiring 200-400 hours of professional time for packages that took 20 minutes to 3 hours to run. Another factor was that student use of terminals was seldom more than 500 hours per year. All considered, the cost from the national stance was estimated at about US $10-20 per student hour, and it could be higher if the number of terminal hours was low. The conclusion was that no cash savings would result from use of the computer.

A controversial part of the program was evaluation procedures. Do students taught via computer learn and retain more than those who are taught by conventional means? A classic test, which meets strict scientific criteria, would have computer-taught subjects in an experimental group compared to subjects taught by a live instructor. Some, however, think that an experiment like this could not be conducted meaningfully because everything must be the same except the human-machine dimension, and no one knows how to do it. The program, therefore, shied from experimental approaches. Instead, the program staff monitored and regulated the progress of its grantees, seeing that they remained on course. The underlying philosophy of the program was development, not research. The value of computer-based learning was assumed, with the only remaining task being to weave it into the fabric of the educational system. Some might see the leap from research to development as premature. Others might say that because the computer is being used as a classroom aid no more harm is done than using an unevaluated instructional film (as most instructional films are).

Computer based learning is now entrenched in the UK; the question is no longer whether it will happen but how it will evolve. The major factor is cost. Software and hardware are expensive. Computer assisted learning and computer managed learning are add-on costs, like audio-visual aids and educational television. Notwithstanding, the government is betting on them. The Council for Educational Technology has been given a four-year follow-on grant from the government to disseminate and coordinate computer assisted learning and computer managed learning, so clearly there is interest in maintaining the momentum. (Jack A. Adams)

SPACE SCIENCES

A SLEIGH RIDE IN SPACE

The European Space Agency's (ESA) Spacelab program is perhaps one of the best known international space technology programs since it will be used in collaboration with the demonstration of NASA's Space Transportation System commonly referred to as the space shuttle. The joint program will demonstrate the feasibility of efficiently utilizing a reusable launch vehicle and allowing nonastronaut scientists to operate in a shirt-sleeve environment in space for an extended period of time. Many experiments of all magnitudes have been proposed and accepted for use in Spacelab from many nations and various institutions both public and private. An experiment that presents numerous interesting aspects to technologists, astronauts, and physicians alike is known as the Space Sled or Vestibular Sled. The Space Sled Facility will emphasize the study of linear acceleration effects on humans. Previous experiments with angular acceleration in the NASA Skylab Rotating Chair have shown no correlation of motion sickness symptoms with the performance of astronauts. A number of details of the Sled program underway at ESA will be presented after a brief review of the agency and its operation.

Previous *ESN* articles have described the ESA operation and its scientific programs, particularly the article by Meredith entitled "Space in Europe" (*ESN* 30-9:385). ESA has come a long way since that time with the launch of the GEOS scientific satellite, the METEOSAT weather satellite, and the OTS communication satellite among others. All of these satellites were developed and built in Europe under the auspices of ESA and its primary corporate laboratory facility, ESTEC (European Space Research and Technology Centre). All of the member states of ESA, namely Belgium, Denmark, France, FRG, Italy, The Netherlands, Spain, Sweden, Switzerland, the UK, and Ireland (which has been approved for membership), have participated in various programs. In addition to member nations, Austria, Canada, and Norway each have observer status, and ESA participates closely with the US particularly in the scientific payload and launch vehicle realm. To try to detail the entire ESA operation would be similiar to writing a treatise on NASA, but a few salient features will be presented in the way of review as the author has had the recent opportunity of visiting various staff members and facilities of ESA headquarters and ESTEC. Cooperative European space activities began in earnest in 1964 with the creation of the European Space Research Organization (ESRO) to develop scientific satellites and the European Launcher Development Organization (ELDO) to develop launch vehicles.

The European Space Agency came into existence in 1975 with the combining of ESRO and ELDO into one agency. The Agency's policy-making body is the ESA Council, composed of representatives of the member states. The chief executive and legal representative of the Agency is its Director General, currently Mr. Roy Gibson, with whom I have recently had a most interesting and informative visit. He is assisted by eight Directors having responsibilities in the following areas: Scientific and Meteorological Programs, Communication Satellite Programs, Spacelab, Planning and Future Programs, Administration, Technical Inspection, ESTEC, and the European Operations Center (ESOC). The main aims of ESA are to (1) Provide and promote for exclusively peaceful purposes cooperation between European states in the fields of space research, technology, and applications; (2) Elaborate and implement a long-term European space policy and program; (3) Progressively "Europeanise" national space programs within the member nations; and (4) Elaborate and implement an industrial policy. These aims sound fine on paper, but their implementation almost defies imagination. Recent outstanding successes can be largely attributed to Mr. Gibson's unrelenting efforts and his very extensive technical and diplomatic experience. The successes of certain large programs are known to involve discussions between heads of state tied as they are to extensive contributions to the Agency budget by states, such as the UK, France, and Germany and their desire to achieve an equitable return as set out in the ESA charter. The 11 member states of ESA contribute to the Agency's finances on the basis of a percentage of their gross national product for general and scientific budgets and on an *à la carte* basis to certain other programs such as Spacelab and the Ariane launcher. Contributions are also made by observer countries. The total ESA budget for 1977 was approximately $550 million. Its total staff consists of about 750 engineers and scientists, 180 technicians, and 570 support personnel drawn principally from the member and observer nations.

ESTEC is ESA's largest research establishment and is responsible for the study, design, development, and testing of components and complete space vehicles for research and applications. This mission is carried out both in-house and through contracts with industry and state government agencies. The ESTEC staff comprises approximately 80% of the entire ESA complement. Located approximately 35 km from Amsterdam, at Noordwijk, ESTEC represents a capital investment of about $70 million. The main facilities include: satellite integration halls, dynamic test chambers, thermal vacuum chambers, a magnetic test laboratory, vibration test facilities, a mechanical test centrifuge, a space batteries test laboratory, and the various other laboratories and workshops associated with a satellite test and assembly facility. It is the intent of ESA and ESTEC to contract for as much assembly and testing as possible to member nations, where such facilities are available, in order to strengthen national competence in specific areas.

In addition to ESTEC, ESA operates ESOC which is responsible for the control of satellites at launch and in orbit, for spacecraft tracking, and for acquisition and processing of satellite data. ESOC headquarters are located in Darmstadt, Germany, with tracking and telemetry stations in Belgium, Germany, Italy, and Spain and with additional mobile ground stations in Fiji, Tahiti, Hawaii, Singapore, Easter Island and on board the Dutch ship *CANDIDE* in the South Pacific. ESA also operates space documentation service, ESRIN, in Frascati, Italy, that offers an advanced computerized system for on-line information retrieval from various scientific and technical data-bases.

Meanwhile back at the Vestibular Sled Facility we find a unique research tool designed to investigate the human neuro-vestibular system in the absence of certain other physical sensations by using the near-zero gravity environment. However, as most graduate students learn if they have a classical physicist sitting on their doctoral orals (usually by giving an incorrect answer), earth orbiting satellites have only one force acting upon them and that is the Earth's gravity. The student is, of course, expected to neglect the forces of the solar wind, photon bombardment, and other third- and fourth-order forces as well as those initiated on-board. The near-zero gravity effect is produced by the combined action-reaction of the Earth's gravitational force and the satellite's angular acceleration (imparted by its injection velocity). The graduate student also is hopefully aware that the human balance organs are located in the inner ear. What he may not realize (unless he is majoring in the biological sciences field) is that these organs have two main systems, one known as the otolith that senses linear accelerations, and the other as the semicircular canal system that senses angular accelerations, and that collectively these are referred to as the vestibular organs, and hence the "Vestibular Sled."

The Space Sled Facility is a life sciences experiment in which a Spacelab crew member will be secured in a movable seat gimballed around two axes to obtain any desired orientation. The seat will traverse back and forth along two rails spanning the length of the Spacelab module. A second crew member located at the Sled control console will initiate each experimental run, monitor the equipment performance and, if required, actuate an emergency stop. Acceleration/deceleration control will be accomplished by means of a programmable profile generator. The test subject will not be able to detect acceleration changes other than through senses of the vestibular organs. Visual perception will be prevented by enclosing the subject's head while noise and vibration levels will be kept below the thresholds for perception. The latter requirements demand an advanced guidance and control system which will be new to space applications.

The principal goals of the Space Sled Facility are to gain a better understanding of the human equilibrium adaptation process in a near zero-g environment and to find methods to alleviate the problems of space motion sickness experienced by man during space missions. This is to be accomplished by analyzing the response mechanism of the human balance system to acceleration forces which are not adversely affected by earth-bound gravitational forces; investigating the relative interactions between inertial balance, visual, audio, and other physical sensations processed by the human brain to elicit automatic and conscious responses to motion perception; understanding and finding ways to enable prediction of crew member susceptibility to space sickness; defining possible training methods for conditioning the human balance system; and studying the adaptation mechanism of the sensory balance system after exposure to a near zero-g environment.

The experimental system has five main components. A TV system is incorporated with a two-fold mission: the first is to provide a visual stimulation to the test subject in order to evaluate optical responses with and without the presence of linear acceleration; the second is to investigate target setting whereby a control handle on the Sled controls the position of an image on a TV screen in front of one eye of the test subject. (The subject is able to move the control handle in the direction of perceived acceleration and control the amount of hand movement by visual checking of the TV image position.) A third component of the experiment consists of a weak infrared source trained on the second eye of the subject so that the eye-roll movements in re-

sponse to various stimuli, including acceleration, can be recorded by an infrared camera. Thermal earplugs, one heated and one cooled will be positioned in each of the subject's ears providing a new experimental technique designed to modify the responses of the vestibular organs in a controlled and reproducible manner. This experiment will also be performed in near zero-g conditions, with and without the presence of linear acceleration. Physical measurement sensors will be utilized to record eye movements, brain waves, respiration, and heart and other muscle responses to various conditions of acceleration. Finally, the Sled Facility will contain a communications system whereby continuous voice contact will be maintained between the test subject, the control console operator, and the scientist investigator on the ground. All signals will be transmitted to the ground, and a quick-look analysis capability will be provided by the Sled Facility to ensure that all signals are working and that the accelerations experienced by the subject are within acceptable limits.

The salient physical characteristics of the Sled Facility are its runway length of about 4.0 m, a total mass of approximately 160 kg, and its capability to accommodate a test subject between 152 and 190 cm in height with a mass of 48 to 91 kg. The Sled Facility provides three different types of acceleration profiles that can be repeated many times during one mission (depending upon the amount of Dramamine the subject has been allowed). These modes are: (1) one-way utilization in which the sled is accelerated at a constant value for scientific measurements and then decelerated to stop at the end of the runway. The acceleration and deceleration values can be selected independently on a continuous scale between 0.001 g and 0.2 g for any run. In addition, deceleration up to 3.0 g can be selected to maximize the measurement time during the acceleration phase; (2) constant-g oscillations in which a minimum of 6 oscillations can be carried out utilizing the free runway length; (3) sinusoidal oscillations which can be performed up to a maximum duration of 10 minutes and where the highest preselectable frequency is 1.0 Hz.

The Space Sled Facility represents a significant tool for the advancement of space medicine investigations. An approved ESA program, it entered the definition phase in 1977 and will shortly enter the main development stage. (Robert W. Rostron)

NEWS & NOTES

ONRL NEWS

It is with deep regret that we announce the death on 18 June of a recent colleague and Liaison Scientist (August 1976 - September 1977), Professor Abraham Sosin, at the age of 52. Since December 1967 he was associated with the University of Utah, Salt Lake City where he was Associate Dean of Engineering, Professor of Physics, and Professor of Materials Science and Engineering. The Materials Department includes all major materials types and under Sosin's direction achieved particular prominence in ceramics, polymers, bio-materials, and flammability research. Sosin's own research was in the field of lattice defects in crystalline materials, radiation effects, kinetic and diffusional processes and theory, internal friction, and chemical vapor deposition. He authored some 80 journal publications, co-authored major reviews in book form, and co-edited a number of books on materials. Before coming to ONRL, he originated and worked on a project on the sodium/sulfur high-temperature battery, of which the work on the alumina solid electrolyte attracted great attention. While with ONRL, he became interested in other forms of energy and wrote many articles for *ESN* on these, the latest on wave-power, appearing in our April 1978 issue.

We extend our heartfelt sympathy to his wife and family and to his colleagues.

QUEEN'S BIRTHDAY HONOURS LIST

In the Queen's Birthday Honours List the following were awarded the KB (Knight Bachelor): Amos Henry Chilver, Vice-Chancellor, Cranfield Institute of Technology, Hans Leo Kornberg, Sir William Dunn Professor of Biochemistry, University of Cambridge; William d'Auvergne Maycock, Director, Blood Products Laboratory, Lister Institute; and Professor Harry Raymond Pitt, Vice-

Chancellor, Reading University. A.W. Woodruff, Professor of Clinical Tropical Medicine, was awarded a Companion of St. Michael and St. George (CMG). Named Companions of the British Empire (CBE) were D.J. Crisp, Professor of Marine Biology, University College of North Wales and M.O. Robins, Director, Astronomy, Space, Radio, and Science of the Science Research Council.

PERSONAL

The Royal Society's 1978 Appleton Prize for Ionospheric Physics has been awarded to Professor P. Banks, Head of the Physics Department, Utah State University. This triennial award, established in 1966, will be presented at a special session of the International Union of Radio Science's general assembly in Helsinki on 2 August.

Professor Sir Derek Barton, FRS, Nobel Laureate, will retire from the Hofman Chair of Organic Chemistry, Imperial College of Science and Technology, in September. He will take up a new career as Director of the Institut de Chemie des Substances Naturelles of the CNRS at Gif-sur-Yvette, France.

Professor J.H. Bird, Head of Geography at the University of Southampton, has been appointed a deputy Vice-Chancellor for four years.

Professor H.A. Chadwick, Professor of Metallurgy and Materials at the University of Queensland, Australia, has been appointed to the Chair of Engineering Materials at the University of Southampton. He will take up his position 1 September 1978.

Sir Frederick Dainton, Chairman of the University Grants Committee, is to be the next Chancellor of Sheffield University. He succeeds Lord Butler, who resigned last year.

Dr. Anselm C. Dunham, Senior Lecturer in Geology at the University of Manchester, has been appointed to the Chair of Industrial Mineralogy at the University of Hull, from 1 October 1978.

Dr. H.G. Heller, Reader in Chemistry at the University College of Wales, Aberystwyth, has been appointed to a personal Chair in Organic Chemistry.

Dr. Anthony S. Laughton has been appointed Director of the Institute of Oceanographic Sciences, Wormley, Surrey. He succeeds Professor Henry Charnock who has taken up the Chair of Physical Oceanography at the University of Southampton.

At the University of Bristol, Dr. J. MacMillan has been appointed to a personal Chair in Organic Chemistry.

Dr. B.D. Sleeman, Reader in the Department of Mathematics at the University of Dundee, has been promoted to a personal Chair in Applied Analysis in the Department.

OBITUARIES

Professor Douglas Richard Chick, Head of the Department of Electronic and Electrical Engineering at the University of Surrey, died on 11 June at the age of 61. His professional career started at the Signals Experimental Establishment (1937-39) where he worked on R&D of military radio and radio jamming. During WWII he was responsible for setting up and directing research activities in basic nuclear physics and in engineering of high voltage Van de Graaff machines and plasma physics aimed at controlling fusion. He directed the design and operation of a 5-MW light-water nuclear reactor for materials research. In 1963 he joined the Vickers Company Research Laboratory, and in 1966 he became head of the Department of Electronic and Electrical Engineering at Surrey. In 1966 he initiated research work on ion implantation well before industry recognized its importance in microelectronics. Today, his Department is one of the internationally recognized centers of excellence in this area. He was also responsible for setting up an industrial Electronics Unit which made the expertise of his academic staff available to industry on a contract research basis.

Professor Maurizio Enrico Federici, Professor of Electrical Communications at the University of Genoa, died in Milan, 10 October 1977 at the age of 73. Graduating in 1925 from the University of Rome, he immediately became an assistant professor. In 1929 he was granted an MSc in Engineering at Harvard and spent the following years working in New York, London, and Berlin. In 1931 he became Technical Manager of the S.A.F.A.R. Research Laboratory in Milan where he planned the first active and passive sonars to be used by the Italian Navy. From 1951 onwards he was Technical Manager and afterwards Director of Marconi Italiana S.p.A., Genoa. In 1965 he was appointed Professor of Electrical Communications at the University of Genoa and

conferred the highest award by the Italian Republic. During the same period he was the Italian representative on the Scientific Committee of the SACLANT ASW (Antisubmarine Warfare Center) at La Spezia. He was the author of the book *Underwater Acoustics*.

Professor William Kearton, formerly Harrison Professor of Mechanical Engineering at the University of Liverpool, died 29 May at the age of 85. During WWI he worked as a steam turbine designer, which was the starting point of his outstanding career as an authority on the design, construction, and operation of steam turbine power plant and other forms of turbomachinery. After WWI he returned to Liverpool as a member of the staff where he established his reputation in the field of power generation through the publication of a number of books and papers. In 1947 he was appointed to the Harrison Chair of Mechanical Engineering. In 1958 on his retirement, the University of Liverpool named him Professor Emeritus.

Professor Ronald George Wreyford Norrish, FRS, Nobel laureate, died 7 June at the age of 80. From 1937 to 1965 he was Director of the Department of Chemistry at the University of Cambridge. Norrish made important and lasting contributions to our understanding of the factors that affect the rates of chemical reactions. He was one of the first chemists to realize the value of high vacuum techniques for handling gases, and the utility and power of absorption spectroscopy for identifying the intermediates and the products of thermal and photochemical gas reactions. Jointly with several colleagues he developed the techniques of flash photolysis and flash spectroscopy which greatly extended studies of the rapid reactions of free atoms and radicals. This joint research with Professor George Porter (now Sir George Porter) won for them the Nobel Prize in Chemistry in 1957 which they shared with Manfred Eigen. He received many honors during his lifetime, and although he had retired, after receiving the Nobel Prize he became quite active for several years and traveled widely to deliver lectures.

Professor Michel Magat, for 40 years one of Europe's best-known physical chemists, died in mid June in Paris at the age of 70. Born in the Ukraine, he studied in Germany and later joined Professor Edmond Bauer at the Sorbonne where he worked on electrical and spectroscopic studies of molecular systems. During WWII, as a member of the Free French Forces, he worked at Princeton University developing the study of polymer materials, especially their interactions with high energy radiation. He continued this line of research back in France for the next 30 years. He was much involved during the '50s in breathing new life into France's organized scientific effort, and the enormous contribution which the CNRS (Centre National de la Recherche Scientifique) has made in this respect should, at least in the physio-chemical field, be credited to Magat. He was recently elected honorary life president of the Société de Chemie Physique and was currently Vice President of the Faraday Division of the Chemical Society (London).

Théodore Vogel, formerly Director of the Physics Research Center of the CNRS at Marseille, France, died in March. He was the publisher as well as French editor of *Acustica*.

ONRL REPORTS

C-3-78 SYMPOSIUM ON FUNCTIONS OF MICROBIAL MEMBRANES, TÜBINGEN, GERMANY, 5-7 SEPTEMBER 1977 by J.E. Sippel

A discussion of some of the papers presented at the Symposium on Functions of Microbial Membranes, which was held at the University of Tübingen, 5-7 September 1977. A complete list of papers given at the Symposium is included as an appendix.

R-1-78 SUPERCONDUCTING MICROWAVE CAVITY RESEARCH AT SIEMENS by F.C. Essig

Information derived from a visit to Siemens AG, Erlangen, FRG, to discuss their work on superconducting microwave cavities is presented. The results obtained with niobium and niobium tin (Nb_3Sn) over the last few years are reviewed. Siemens' current interests are to continue work with Nb_3Sn, to explore new TM-cavity designs, improve cavity reproducibility, and to produce less expensive cavities.

R-2-78 UNDERWATER INSPECTION AND NONDESTRUCTIVE TESTING OF OFFSHORE STRUCTURES by R.L. Brackett

Regulations have been established by the governments of countries bordering the North Sea which require annual inspection of offshore structures. This has resulted in a much more intensive use of Nondestructive Testing (NDT) techniques for underwater inspection than currently exists in the United States. This report presents a review of the NDT techniques and equipment currently used in the North Sea area and discusses some of the research being conducted in the UK and Norway to improve the quality of underwater NDT inspection.